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Estimating Early Language Input in Deaf and Hard of Hearing Children With the Language Access Profile Tool

Matthew L. Hall[a] **and Stephanie De Anda**[b]

[a] Department of Communication Sciences and Disorders, Temple University, Philadelphia, PA [b] Department of Special Education and Clinical Sciences, University of Oregon, Eugene

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ABSTRACT

Purpose: The purpose of this study was to describe the Language Access Profile Tool (LAPT) and its psychometric properties with the aim of evaluating its suitability as an alternative to the deaf or hard of hearing (DHH) Language Exposure Assessment Tool (D-LEAT) in clinical practice with DHH children age 12 years and younger.
Method: We administered both the LAPT and D-LEAT to the caregivers of 105 DHH children 12 years old and younger from across the United States, 40% of whom were interviewed again after a delay of at least 1 month. Each interview resulted in a child-specific estimate of their cumulative experience with language input, expressed as a proportion divided across eight categories.
Results: Participants in the sample reported experience with all eight input categories, but four categories were common and four were rare. Estimates for all input categories were consistent at both initial and follow-up interviews. Estimates for each input category were also strongly correlated with the corresponding estimates from the D-LEAT, although correlations for the rare categories should be interpreted cautiously.
Conclusions: The LAPT demonstrates sufficient test–retest reliability and convergent validity to be a useful and more user-friendly alternative to the D-LEAT. We provide recommendations for how the LAPT and the D-LEAT can be best used in their current form.
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Collecting information about a client's language history is considered best practice within speech-language pathology, especially when working with culturally and linguistically diverse populations (American Speech-Language-Hearing Association [ASHA], n.d.-a). A well-documented language history includes not just a record of the client's outcomes on language assessments, but also the contexts in which the language(s) are used, and the type, timing, quantity, and quality of various languages in the input (ASHA, n.d.-a). In recognition of the important role that language history plays in clinical practice, there are a number of tools available to help clinicians document this information (for a recent review, see Kašćelan et al., 2021).

There is strong rationale to support the use of language history measures in clinical contexts. First, capturing language history is central to any assessment of a client's present language abilities and follows best practices (Shipley & McAfee, 2019). For example, if a school-age child shows absent language milestones compared to their peers, a careful language history can help determine the interpretation of such assessment findings. If the child's history shows they only started learning the language recently, there would be relatively less cause for concern compared to a child who had been learning the language in the 0- to 3-year age period. Beyond interpretation of findings, language histories support basic assessment and treatment procedures.

Traditionally, some of the information about language history is collected via a case history. Indeed, a thorough

Correspondence to Matthew L. Hall: matthall@temple.edu. ***Disclosure:*** *The authors have declared that no competing financial or nonfinancial interests existed at the time of publication.*

language history can help identify the target language(s) to be assessed and treated and describe the types of language varieties in the child's environment. A language history can also support classification of language transfer or linguistic differences versus true errors. For example, clinicians employ contrastive analyses that support identification of true speech-language errors by examining whether the patterns in the client's productions are consistent with the child's language learning history, or a true error that is not explained by cross-linguistic transfer (e.g., McGregor et al., 1997). Indeed, cross-language transfer of speech and language patterns is a typical phenomenon of language acquisition in multilingual contexts (e.g., Fabiano-Smith & Goldstein, 2010) and language histories help confirm whether an observed pattern can be explained by the language learning environment. Lastly, language histories yield information about cultural considerations surrounding the child's contact with different languages and plans for future communicative needs.

Second, a detailed and thorough case history can aid in reducing bias in service delivery. The Word Health Organizations International Classification of Functioning (ICF) Disability and Health model states that practitioners must understand the client's individual context, including characterization of the environment (Üstün et al., 2003). In part, language histories provide a window into the child's language environment that informs ongoing assessment and treatment planning to ensure services are responsive to the client's idiosyncratic context.

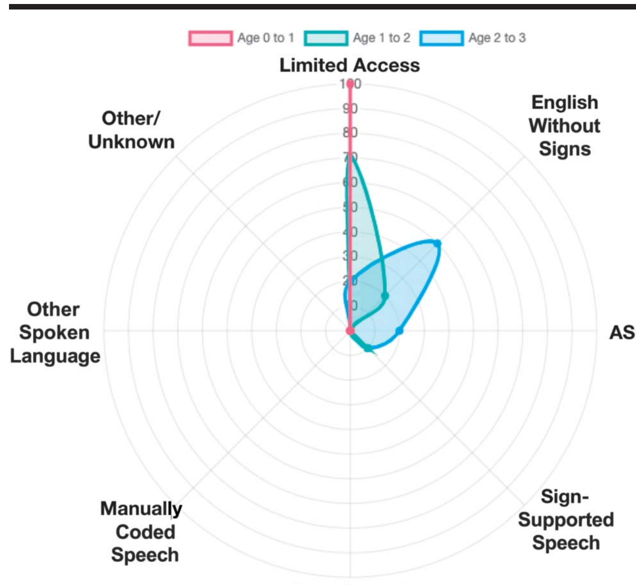
No two deaf or hard of hearing (DHH) children have the same language environment, and a single child may have a widely variable language learning history. The 0–3 age period can be complex as families navigate interventions and different language input types to facilitate communication, especially for the many DHH children being raised among hearing families (Crowe et al., 2012; Pedersen et al., 2021; Porter et al., 2018; Stredler-Brown, 2010). Practitioners are called upon to respond to these individual differences and to tailor and adapt services to such diversity. Although there exist a number of tools for describing language history, only recently have adaptations been made to be culturally and linguistically responsive to the needs of DHH children in the United States.

Measuring DHH Children's Cumulative Experience With Language Input

The DHH Language Exposure Assessment Tool (D-LEAT) was recently introduced as the first tool specifically designed to quantitatively estimate DHH children's experience with different forms of language input during the crucial language-learning years of infancy and toddlerhood (Hall & De Anda, 2021). The D-LEAT was adapted from the Language Exposure Assessment Tool (LEAT; DeAnda et al., 2016), which uses a spreadsheet-supported interview protocol to systematically identify how much time a child spends communicating with the primary interlocutors, what languages are used in those interactions, and in what proportion. Two major adaptions allow the D-LEAT to capture the experiences of DHH children. First, the D-LEAT differentiates among various types of manual communication that are linguistically distinct (natural sign languages, sign-supported spoken languages, manually coded versions of spoken languages, and cued language). Second, the D-LEAT estimates the extent of a child's perceptual access to the linguistic input in their environment, recognizing that some DHH children do not gain perceptual access to linguistic input for several months or even years (Levine et al., 2016), and that even after the initial onset of language access, DHH children's access to language input may still be limited by perceptual factors (e.g., hearing devices providing improved but not complete perceptual access even when worn) and environmental factors (e.g., noisy environments, inconsistent device use, inconsistent use of visually accessible communication). We refer to this category of input as *limited access*. Like the original LEAT (and most current approaches to characterizing multilingual language input; Kašćelan et al., 2021), the D-LEAT represents a child's experience with different forms of input as a proportional distribution of 100% across the relevant categories of input.

One way to visualize these data are in a radar chart, where the center represents 0% and the outermost edge represents 100%. Figure 1 illustrates the profile of a child

Figure 1. Graphical output of the Language Access Profile Tool, representing one child's language access profile in 1 year increments. The center represents 0%, with 100% at the outermost edge. Together, the values on each axis sum to 100% for each time point.



who had no access to language input during the first year of life (captured on the "limited access" axis), but gained some access to both spoken English (estimated at 20%) and sign-supported speech (10%) during the second year, with limited access decreasing from 100% in Year 1 to 70% in Year 2. In Year 3, limited access decreases further as the child's auditory access to spoken English increases from 20% to 50%. These decreases in limited access reflect the perceived impact of multiple factors, such as increased wear time, better fitting/mapping, transition from hearing aids to cochlear implants (CIs), reduced background noise, and so forth. For children with typical or corrected vision, another factor that reduces limited access is if more of the child's time is spent in environments where there is visual access to language input. In this case, although sign-supported speech held steady at 10%, American Sign Language (ASL) increased from 0% to 20% during Year 3.

Reporting on Infancy and Toddlerhood in Younger Versus Older Children

Because infancy and toddlerhood are crucial language-learning years, the child's experience with input during this window has a lasting impact on their subsequent development (Levine et al., 2016). Therefore, Hall and De Anda (2021) included families whose DHH children were under age 3 years and those whose children were older (age 3–12 years). Because the reporting period always focuses on 0–3 years, parents of infants/toddlers report about the recent past, whereas parents of older children report about the more distant past. This is a potential liability: Parents of older children may be less confident in the estimates they provided. Regrettably, no measures of parent confidence for D-LEAT interviews were reported.

Hall and De Anda (2021) also note that for children younger than age 3 years, it would be possible to administer the D-LEAT repeatedly (e.g., every 6 months), which has three advantages. First, reporting on a smaller window (e.g., 6 months vs. 3 years) shortens the administration time. Second, it reduces the memory burden on the parent. Third, it provides opportunities to recommend and monitor specific and measurable goals for language input while the child is still within the reporting period. Thus, although the D-LEAT was validated for use with children up to age 12 years, it was especially recommended for children who were still within the 0–3 years reporting period. This leaves open the possibility that other approaches might be better suited for clinical work with DHH children ages 3–12 years.

The Language Access Profile Tool

Currently, only one alternative to the D-LEAT exists: the Language Access Profile Tool (LAPT), which was also introduced in Hall and De Anda (2021) but not described or analyzed in detail. Rather than asking parents to report on detailed, time-based interactions with specific interlocutors, the LAPT asks parents to provide a more direct overall estimate of their child's early experience with language input by distributing 100% across the same input categories, in bins of 10% each. It captures change over time by asking parents to provide separate estimates for age 0–1 year, 1–2 years, and 2–3 years. As such, it is less complex and less time-intensive to administer. Therefore, if it returns similar results as the D-LEAT, it may be preferable for clinical use, at least with children age 3 years and over. However, because parents of older children would still need to think back as many as 9–12 years in the past, measuring their confidence in the estimates they provide is a reasonable first step to determining whether there is an age past which the LAPT should not be used. Although high confidence does not guarantee high accuracy, low confidence would cast doubt on the appropriateness of the method.

The LAPT may also have other liabilities. Although it can be used with children ages 3 years and under, it does not provide detailed information about who communicates with the child in what ways, which lessens its potential impact for intervention planning. In addition, it can be administered no more frequently than every 12 months. In addition, because the LAPT only captures input bins of 10% (with rounding), it is—by design—less sensitive to forms of communication that may be present but constitute less than 10% of a child's input. Finally, it remains to be seen whether these methods succeed in yielding similar estimates to those obtained by the D-LEAT. If so, this would facilitate collecting language access profiles for clinicians who have limited time or who are uncomfortable with entering formulas into spreadsheets (as the D-LEAT requires). This increased efficiency may also appeal to those who are more interested in language access profiles for the purposes of research rather than clinical care.

To date, the only published analysis of LAPT data is an analysis of its convergent validity with the D-LEAT, which was found to be very good (Hall & De Anda, 2021). However, this analysis was based on the child's overall distribution of input across all categories simultaneously. A more clinically relevant question is whether these two tools provide similar estimates for individual input categories, and if so, whether this agreement extends to both frequent and infrequent categories.

For example, if a family has established a goal of providing at least 20% of the child's input in cued speech, it is relevant to know whether the D-LEAT and LAPT yield similar estimates for that category specifically.

The previous analysis leaves this question unanswered. Similarly, no previous research has examined the test–retest reliability of the LAPT; if this tool is to be used in clinical practice, it is essential that repeated administrations elicit consistent responses.

In light of the above, the objectives of this research study are to (a) provide the first thorough description of the LAPT and its administration, (b) measure parent confidence in retrospective report, (c) evaluate convergent validity between the LAPT and the D-LEAT for each input category, and (d) evaluate the test–retest reliability of the LAPT for each input category. The tool will be tested with caregivers whose children are currently 12 years old and younger. Regardless of the child's current age, the reporting period focuses on infancy and toddlerhood (0–3 years), because this is the period during which language input is the primary determinant of language outcomes (Houston, 2022; Moeller & Tomblin, 2015).

Method

The methods of this study were approved by the institutional review boards (IRBs) at the University of Connecticut and the University of Massachusetts–Dartmouth; all participants gave their informed consent to participate.

Participants

We interviewed the primary caregivers of 105 DHH children from across the United States; these were the same participants previously described in Hall and De Anda (2021). Participants were eligible if their child was currently age 12 years or younger, with a permanent hearing loss of any type, degree, laterality, or etiology that was known or suspected to have begun before age 3 years. Twenty-six participants were younger than 3 years old at the initial interview. Table 1 presents demographics for the parents; Table 2 presents demographics for the children. For more details on recruitment, see Hall and De Anda (2021). Participants were paid $10/hr in the form of electronic gift cards.

Measures

LAPT

The LAPT is a technology-supported interview protocol; although it can be conducted in person, all interviews in this study were conducted remotely, via telephone, videophone, or videoconferencing technology.

The LAPT interview begins with a "warm-up" period by introducing the conceptual distinction between "language exposure" (defined as communicative signals *sent to* the child) and "language access" (communicative

Table 1. Caregiver demographics.

Question	Options	*n* (105 total)
Relationship to child		
	Biological parent and primary caregiver	93
	Not biological parent but primary caregiver	11
	Unknown/not reported	1
Education		
	Less than high school	1
	High school or GED	3
	Some college or associates	14
	College degree	39
	Graduate study or advanced degree	43
	Unknown/not reported	5
Interview in		
	English	90
	ASL	15
	Spanish	0
Race		
	White	94
	Asian	2
	More than one	1
	Black or African American	1
	Pacific islander	1
	Unknown/not reported	5
Ethnicity		
	Not Hispanic or Latino	96
	Hispanic or Latino	6
	Unknown/not reported	3

Note. GED = General Educational Development; ASL = American Sign Language.

Table 2. Child demographics.

Question	Options						*n* (105 total)
Age level (years;months)							
	Infant (0–1;5)						11
	Toddler (1;6–2;11)						15
	Preschool (3;0–4;11)						20
	School-age (5;0–12;11)						59
Gender							
	Male						53
	Female						52
	Other						0
Hearing levels (binaurally)		Typical	Mild	Moderate	Severe	Profound	Unsure
	Typical	0	0	3	1	3	0
	Mild		2	7	2	1	0
	Moderate			9	4	6	0
	Severe				3	9	0
	Profound					48	0
	Unsure						5
Hearing status of caregivers							
	All hearing						84
	All DHH						15
	At least one hearing and one DHH						6
Experience with hearing aids							
	Consistent use						37
	Used in the past, now switched to different technology						30
	None						10
	“Other” HA use						9
	Consistent use in combination with other hearing technology						8
	Used in the past but not present						5
	Inconsistent use						4
	Unknown/not reported						2
Experience with cochlear implants							
	None						59
	Consistent use						30
	CI use in combination with other hearing technology						7
	“Other” CI use						5
	Inconsistent CI use						2
	Unknown/not reported						2

Note. DHH = deaf or hard of hearing; HA = hearing aid; CI = cochlear implant.

signals *received by* the child), and explaining that the goal was to estimate the child’s language access between birth and age 3 years. The warm-up phase continues by introducing the interviewee to the eight input categories that the LAPT uses.

The first category to be explained is limited access (which was labeled “Indirect Access” during this study). This category aims to capture the extent to which a DHH child did not have direct perceptual access to the linguistic signals that were being sent. This category is intended to include both (a) time that elapsed prior to the onset of perceptual access to any form of input and also (b) the extent of a child’s perceptual access to the communicative signals in their environment for the remainder of infancy and toddlerhood. For example, a child born with profound hearing levels bilaterally would be considered to experience 100% limited access until CI activation, unless a form of linguistically structured visual communication was used prior to that point. Upon CI activation, this child may continue to experience limited access, which could reflect both periods of nonuse/malfunction and less than full perceptual access to spoken language even when the device is worn and well mapped. Similarly, a Deaf–Blind child raised in a signing environment would be considered to experience limited access when tactile communication was not used, and to the extent that their visual abilities do not allow access to visual communication. If a child did not have perceptual access to any input during infancy and toddlerhood, their profile would consist of 100% limited access. Whereas the D-LEAT solicits each component separately and then combines them, the LAPT collects a single estimate that is intended to reflect both components.

The remaining categories are English without signs, ASL, sign-supported speech, cued speech, manually coded English, other spoken language, and other/unknown. Descriptions of ASL, sign-supported speech, cued speech, and manually coded English were accompanied by example videos to ensure that interviewees understood what we meant by these distinctions. The main distinction between ASL and the latter three is that the structure of the other three is governed by the grammar of English, rather than the grammar of ASL. The main distinctions among the latter three are that sign-supported speech typically highlights content words, cued speech supplies phonological information (for disambiguating words whose articulation is visually similar), and manually coded English foregrounds morphosyntactic information.

The other/unknown category is included to account for children whose experiences might be uncommon or complex. Examples of “other” would include natural sign languages other than ASL; cued-, sign-supported, or manually coded versions of spoken languages other than English; and homesign. Examples of “unknown” would include cases such as adoption, foster care, or split custody, if the interviewee did not have information about the child’s experience for significant portions of their life. Although these are heterogeneous experiences, they are collapsed into a single category on the assumption that these would be relatively uncommon both across and within children, and that few, if any, children would have more than one type of experience that belonged in this category; this was in fact the case.

As each input category is introduced, the interviewee indicates whether it was or was not a part of their child’s experience during the birth to 3 years of age window; the categories that do not apply are set to “0%” and not discussed further. After eliminating these categories, the warm-up period concluded by asking the parents to think of their child’s experience between birth and age 3 years (or current age, if under 3 years) as 100%, and to divide that 100% across the remaining categories, rounded to the nearest 10%. The software prevents the system from advancing unless responses sum to 100%. The interviewer then proceeds to the next screen, which begins the core interview.

The core interview obtains the same information as in the warm-up phase, but instead of examining the birth to 3 years of age period as a whole, it is divided into 12-month intervals, starting with birth to 12 months. Because the warm-up period typically reveals the major milestones in a child’s experience, the interviewer can use this information to maximize the fidelity of the estimates obtained during each single-year interval. Estimates are obtained only for intervals that are complete; thus, a 30-month-old’s profile would reflect their experience from 0–12 months and 12–24 months, but the 24–36 months interval would not be administered (controlled automatically by the software). At the end of each single-year report, parents were asked to rate how confident they felt in their estimate on a scale of 1 (*not at all confident*) to 5 (*very confident*).

After completing the core interview (typically 15–20 min), standard LAPT administration would then involve a set of optional demographic questions. In this study, those questions were deferred until after administering the D-LEAT. After the demographic questions are completed, the LAPT displays a graphical representation of the child’s experience over the birth to 3 years of age period, showing each individual year along with an average across all relevant years, as shown in Figure 1 (values from the warm-up period are not included). The average across the core interview is considered to represent the child’s cumulative language access profile.

D-LEAT

As noted in the introduction, the D-LEAT (Hall & De Anda, 2021) is adapted from the LEAT (DeAnda et al., 2016), which was developed to measure early experience with language input in hearing children from multilingual families. D-LEAT administration involves three main steps. Step 1 identifies the child’s most frequent interlocutors and the type(s) of communication that each one uses. Step 2 identifies the age (in months) at which the child first gained perceptual access to linguistic input (time prior to this is counted toward limited access). Step 3 documents the child’s schedule of interactions with each interlocutor by identifying (a) the age range (0–36 months) during which the interaction occurred, (b) the usual number of days per week, (c) the usual number of hours per day, (d) that interlocutor’s typical distribution of input types (e.g., 80% English without signs, 20% sign-supported speech), and (e) an estimate of the child’s perceptual access to the input (based on the child’s perceptual abilities, appropriateness and use of assistive technology, and the auditory/visual environment). The child’s schedule of interaction with each interlocutor is subdivided as needed to reflect significant changes in any of the above (e.g., amplification, implantation, changes in communication approaches, shifts in caregiver schedules and/or day care). The spreadsheet automatically calculates the overall percentage of the child’s experience that belongs to each type of input. See Hall and De Anda (2021) for more details.

Procedure

Informed consent was received from all participants, in accordance with the ethical standards of the IRBs at the University of Connecticut and University of Massachusetts–Dartmouth. We also requested participants’ consent to audio- or video-record the interviews, and did so when consent was granted. We then administered the LAPT, followed by the D-LEAT, and ended with a brief demographic survey.

To begin the LAPT, the parent navigated to a website URL that the experimenter supplied, and completed the forms on each page in conversation with the experimenter. The experimenter also filled out the forms on a locally hosted server, to facilitate error checking and prevent data loss due to connectivity issues. Discrepancies were rare and typically resolved by consulting the recording; when recordings were unavailable, the experimenter's copy superseded.

The LAPT was administered as described above, followed by the D-LEAT. Finally, the participant returned to the original website on which the LAPT was hosted and, in conversation with the experimenter, completed a brief demographic survey.

After at least 1 month had passed (to ensure that participants were truly giving authentic estimates rather than simply recollecting the numbers they had given previously), participants were invited to return for a follow-up survey, except as noted below; 53 (50%) returned. The exception is that several families who preferred to use ASL were not invited for the second interview; these were families who had participated in the early stages of the project, at a point when we were still anticipating being able to hire additional ASL-proficient personnel. We, therefore, planned to invite these families once the hire had been made so that they could both observe and eventually conduct LAPT interviews in ASL. By the time it became clear that this was not feasible given our funding situation, nearly a year had passed since the initial round of interviews, and it did not seem appropriate to combine interviews at a 1-year lag with interviews at a 1-month lag. Going forward, all participants were invited to the follow-up interviews, regardless of home language. The second session was structured identically to the first.

Planned Analyses

Confidence

Mean confidence greater than 4/5 (80%) will be considered acceptable. We will also test for a correlation between each child's current age and their parent's mean confidence level. The age at which the regression line crosses below 4/5 (80%) will be the oldest age for which LAPT administration is recommended.

Convergent Validity

Convergent validity evaluates the degree to which a measure is associated with a measure of a similar construct. We expect that language access captured on the LAPT should be strongly and positively associated with language access captured on the D-LEAT. This would lend support the use of the LAPT as an alternative to the D-LEAT.

One analysis of convergent validity between the LAPT and D-LEAT was previously reported in Hall and De Anda (2021); however, this analysis only considered convergence when considering all input categories taken together, and did so in a way that was driven by how children were grouped by applying hierarchical cluster analysis to the D-LEAT. The analyses below are the first to evaluate convergent validity at the level of each individual input category. An error-free instrument would yield a best fit line for each input category of y = 1x + 0, with $r^2 = 1$. Following Cohen (1988), we will consider $r^2 > .25$ as indicating strong agreement. If the distribution of the data violates the assumptions of linear regression, we will adopt a more descriptive/qualitative approach.

Test–Retest Reliability

Test–retest reliability evaluates the extent to which participants give the same responses on a re-administration of a measure, after a sufficiently long delay that they are not merely recalling the responses they gave previously. Therefore, for each input category, we plot the correlation between the LAPT estimate for that category at the initial interview and the follow-up interview. To do so, we will use the same methods described above for convergent validity. Strong positive correlations between responses on the initial and follow-up administrations would be evidence of good test–retest reliability.

Results

Confidence

Mean parent-reported confidence across all ages was 4.39/5 (95% confidence interval [CI] [4.26, 4.52]). There was no correlation between child's current age and confidence, $r(102) = -0.10$, $p = .30$; $r^2 = .01$. The regression line remained above 4.0 across the full range of ages; its lowest point was 4.23, at 155 months (the oldest children tested).

Descriptive Findings

Table 3 presents the mean, median, minimum, and maximum cumulative amount of input for each category across the data set, expressed as a percentage. All eight categories of input were attested in the data set, and to nonnegligible degrees. Indeed, for each category, there was at least one child in the data set for whom that category was reported to constitute 50% or more of their experience with linguistically structured input during infancy and toddlerhood. However, not all categories were equally common. As shown in Table 3, participants reported a broad range of experiences with four of the categories (limited access, English without signs, ASL, and sign-supported speech). We will refer to these four as the "major categories." In contrast, the distributions of the remaining four types of input are almost entirely massed at 0%, with only a few individuals reporting more extensive experience. We will refer to these latter four as the "minor categories" (note that because the distribution of each input category was highly skewed, the values in Table 3 should *not* be taken to represent the experience of "the average DHH child" in the United States).

Table 3. Cumulative input from birth to 3 years (or current age, if younger), convergent validity, and test–retest reliability by input category.

Input category	*M* (*SD*), %	*Mdn* (SIQR), %	Minimum–maximum (%)	Convergent validity with D-LEAT (r^2)	Test–retest reliability (r^2)
Limited access	24.6 (25.0)	21 (20)	0–100	.70	.71
English without visual support	34.4 (32.9)	34 (31)	0–100	.86	.84
American Sign Language	19.0 (29.2)	0 (9.8)	0–100	.98	.95
Sign-supported English	14.6 (17.1)	7 (10.5)	0–73	.50	.39
Cued English*	1.0 (6.5)	0 (0)	0–50	.97	.99
Manually coded English*	2.1 (8.9)	0 (0)	0–67	.70	.17
Other spoken language*	2.9 (8.4)	0 (0)	0–53	.84	.85
Other/unknown*	1.5 (8.6)	0 (0)	0–80	.83	.14

Note. SIQR = semi-interquartile range; D-LEAT = Deaf or Hard-of-Hearing Language Exposure Assessment Tool.

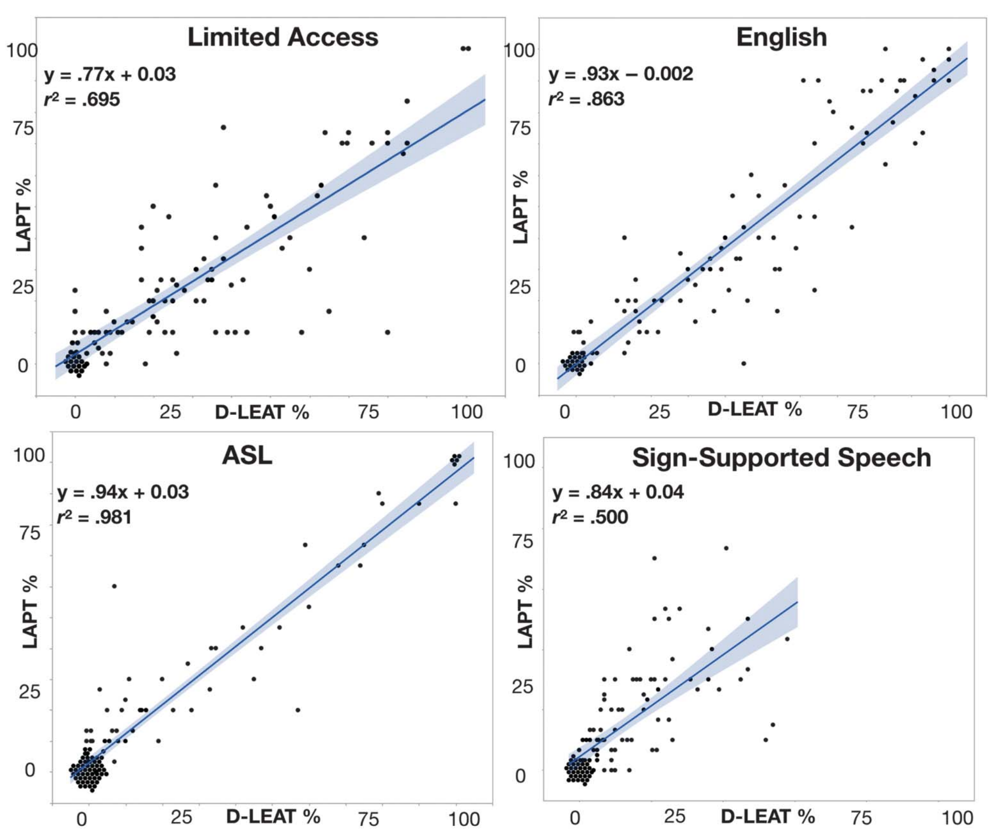
*Categories that were less common in the data set are marked with an asterisk; r^2 values for these categories may be spurious and are provided for completeness.

Supplemental Materials S1 and S2 provide histograms for each input category and individual language access profiles of each child in the data set, respectively.

Convergent Validity With D-LEAT

Figure 2 shows the correspondence between the D-LEAT's estimate and the LAPT's estimate of each major category, for each child in the data set. Because these data distributions met the assumptions of linear regression, we computed Pearson correlations between the values from the LAPT and D-LEAT interviews. Figure 2 plots these correlations for the major categories, together with their associated r^2 values and regression equations. As summarized in Table 3, the correlations for all major categories far exceeded the conventional criterion of $r^2 > .25$, although markedly less so for sign-supported speech.

Figure 2. Correlations between Language Access Profile Tool (LAPT) and Deaf or Hard-of-Hearing Language Exposure Assessment Tool (D-LEAT) estimates for the major input categories (*N* = 105). Overlapping data points are jittered for visibility. ASL = American Sign Language.



Because the distribution of the data for the minor categories is strongly skewed toward 0 for both time points, regressions should be interpreted with caution and are provided in Table 3 mainly for completeness/transparency. When participants reported nonuse of a given category on the LAPT, they almost always reported nonuse on the D-LEAT as well (95% for other spoken language and other/unknown, 99% for manually coded English, 100% for cued speech). Across all categories and all participants, there were only 11 instances where the D-LEAT recorded the presence of an input category that was estimated at 0% on the LAPT. The greatest discrepancy was 6% (n = 1); the other 10 instances were 2% or less.

Supplemental Material S3 plots the analogous correlation for the minor categories. Supplemental Materials S4 and S5 present the same data but additionally indicate naturally occurring groups of children who have had similar overall experiences with language input, as identified through hierarchical cluster analysis (cf. Hall & De Anda, 2021).

Test–Retest Reliability

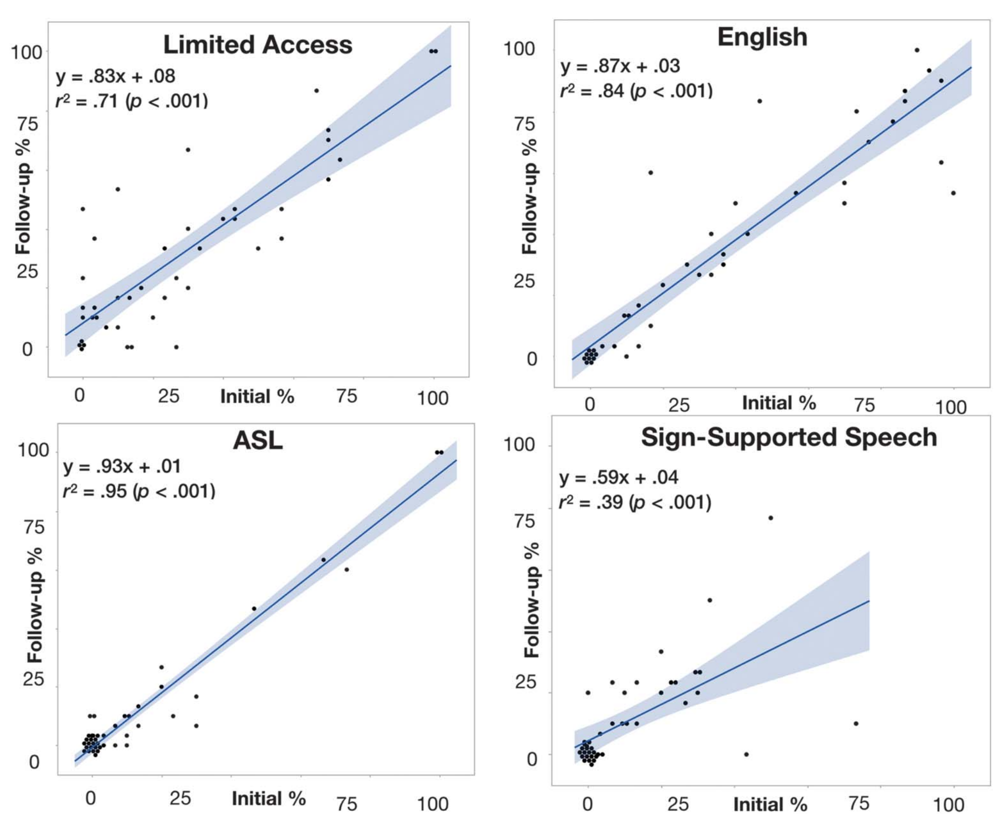
As in Hall and De Anda (2021), we also excluded 10 returning participants who were younger than age 3 years at the initial interview and for whom more than 2 months had passed since the initial interview, because changes at the follow-up interview could reflect true changes in the child's experience, rather than inconsistent reporting. A technical error resulted in the loss of follow-up data from one of the 43 remaining participants, yielding a final sample of 42 returning participants (40%).

As above, the correlations for the major categories are plotted in Figure 3, with their corresponding r^2 values and regression equations. The correlations again far exceed the criterion, as summarized in Table 3. Sign-supported speech, though still strong, remains the weakest of the major categories.

Once again, the minor categories merit a more descriptive approach. Among participants who reported nonuse of a given input category at initial interview, 95% (cued speech, other/unknown) to 98% (manually coded English, other spoken language) also reported nonuse at follow-up.

Supplemental Material S6 plots the analogous correlation for the minor input categories. Supplemental Materials S7 and S8 present the same data but grouped by cluster, as in Supplemental Materials S4 and S5.

Figure 3. Correlations between initial and follow-up Language Access Profile Tool interviews for the major input categories (n = 42). Overlapping data points are jittered for visibility. ASL = American Sign Language.



Discussion

Summary of Findings

This is the first study to describe the Language Access Profile Tool (LAPT), its administration, and the data that it generates. Our analyses focused on evaluating (a) parent-reported confidence, (b) convergent validity between the LAPT and the D-LEAT (Hall & De Anda, 2021), and (c) the test–retest reliability of the LAPT.

Parent-Reported Confidence

Parents generally reported feeling confident in the estimates they provided, and confidence did not significantly change even for parents who were looking back as many as 9–12 years. Although confidence does not guarantee accuracy, low or decreasing confidence would have been a red flag. Given that the D-LEAT did not measure parent confidence at any age, these results provide initial justification for using the LAPT to report on early language input for children whose current age is up to 12 years 11 months.

Convergent Validity Between the LAPT and D-LEAT

Agreement between the LAPT and D-LEAT was strong for all major input categories. Even though sign-supported speech was the weakest of these, the regression coefficient (r = .71) was once again quite high, such that the r^2 value (.50) far exceeds the conventional cutoff of .25. Among the minor categories, it was possible that agreement could have been weaker because the LAPT is relatively insensitive to small amounts of input. Because it uses bins of 10% each, the LAPT may record 0% when in fact the D-LEAT (which is able to document even low amounts of experience) would record nonzero values. This did indeed occur, but only 11 times across the entire data set; in 10 of these instances, the discrepancy was 2% or less. This is likely possible because the final LAPT estimate reflects an average across three separate yearly estimates; Thus, if a given type of input constituted at least 5%–10% of a child's input for 1 year, it will be recorded as 10% for that year and average out to 3.33%. Thus, it appears that the coarser resolution of the LAPT does not substantially compromise the instrument's ability to capture DHH children's experience even with rarer types of input.

Test–Retest Reliability of the LAPT

Estimates of how much of a child's input belonged to a given input category were quite stable across time and across interviewers for the four major categories: limited access, English without sign, ASL, and sign-supported speech. Even though sign-supported speech returned the weakest value among the major axes, its regression coefficient (r = .62) is conventionally considered to be quite strong (Cohen, 1988).

For the four less-frequent categories (cued speech, manually coded English, other spoken language, other/unknown), the vast majority of participants reported 0% at both the initial and follow-up interviews, with only a handful of participants reporting nonzero values. Although the highly skewed nature of these distributions renders linear regression circumspect, two findings are clear. First, participants are very consistent in reporting whether or not their child has had experience with a given type of input. Second, when nonzero estimates are provided, they too tend to be fairly stable across time. Interestingly, discrepancies seem to be greater when estimates are lower. This suggests that the LAPT is most reliable when parents are reporting on the types of input that are the most prevalent in a child's life compared to input that is less consistent.

These data come from the 40% of participants who returned for a follow-up interview and yielded usable data. Because parents of young DHH children have many demands on their time, we were satisfied with this return rate. Still, it is possible that including more of the initial sample would have yielded either a higher or lower estimate of test–retest reliability. To our knowledge, the only factor that could have differentially impacted return rate is that some participants whose initial interview was conducted in ASL were not invited to the follow-up interview, for the reasons described earlier.

Limitations and Future Directions

Any tool that relies on caregiver report is vulnerable to certain types of measurement error (Crowe et al., 2015; Streiner et al., 2015); work on multilingualism in hearing children faces many of these same limitations and has generally adopted analogous solutions (Bedore et al., 2012; DeAnda et al., 2016; Gutiérrez-Clellen & Kreiter, 2003; Pearson et al., 1997; Place & Hoff, 2011). Because the construct that we aim to measure concerns the child's cumulative experience across all environments, the only sure way to collect accurate data would be to constantly surveil the child's surroundings from birth onward, which is as unethical as it is impractical. LENA recorders (Xu et al., 2009) do not solve the problem: They provide no information about the child's experience prior to the arrival of the device, they cannot measure nonauditory input, and the microphone detects the same environmental sounds regardless of the child's hearing levels, hearing technology, and so forth (for more on the limitations of LENA systems as a proxy for language access in DHH populations, see Hall, 2020). Furthermore, the present methods are simply a more informative version of the current practice of obtaining "communication mode" by parent report (Dills & Hall, 2021). Thus, while we acknowledge that LAPT estimates are imperfect, we see no scenario in which the status quo is preferable to the methods reported here.

Another limitation of this study is that the present group of participants was limited in diversity as the overwhelming majority of parents were highly educated and White. More research is needed on those communities that are typically underrepresented in research (e.g., Black and Latine populations). Any application of the LAPT with different communities should include careful cultural and linguistic adaptations following best practices (e.g., Peña, 2007).

Estimating limited access. Both the D-LEAT and the LAPT take a subjective approach to estimating limited access. Although a direct measure or veridical estimate would be desirable, we do not believe that any existing methods fully succeed in doing so. The Speech Intelligibility Index (SII; American National Standards Institute [ANSI], 1997) is an objective measure of how audible the sounds of spoken language are to someone who is unamplified or using a hearing aid. However, SII calculations are not yet defined for CI users. In addition, children whose environments include visually accessible language may have good access even if they have low SII values. Data logging from hearing devices is subject to the same limitations. In light of these challenges, other researchers have also relied on methods that rely on caregiver report or intuition to make inferences about the child's auditory access (Bagatto & Scollie, 2013; Coninx et al., 2009; Kronenberger et al., 2021; Zimmerman-Phillips et al., 1997). However, these methods only provide estimates of the child's experience at a single point in time, whereas the construct that we aim to measure requires a cumulative estimate. And as already noted, these measures also tend to assume that only auditory access counts, which is not a helpful or appropriate assumption. Thus, while we hope that future innovations will surpass the methods we have used here, we maintain that the present approach is already an advance over the status quo insofar as it more clearly identifies the central construct that should be the target of measurement.

Until better estimation methods are available, we recommend that clinicians discuss the parent's estimate of limited access with the child's audiologist. This is consistent with ASHA's goal of fostering interprofessional practice (ASHA, n.d.-b), and presents opportunities to identify and then resolve any major discrepancies between the parental and professional estimates of access to linguistic input. If the audiologist believes that the parental estimate of auditory access is unrealistic, the speech-language pathologist may revise the value in the LAPT system. This also presents a key opportunity for clinical counseling (cf. ASHA, 2016).

Predictive validity. We chose not to measure language outcomes in this study; therefore, we have no data on the predictive validity of the LAPT. The primary rationale is that the relationship between early language input and later language outcomes in DHH children is not yet known. It may be that some language access profiles are more likely to yield stronger (spoken or signed) language outcomes than others; alternatively, it may be that language access profiles account for little to no variance in DHH children's language outcomes. We believe that this is a research question worth pursuing, but it is one whose answer cannot be taken as given, and should, therefore, not be used to establish the validity of the methods used for measuring language input; to do so would be circular. Having now established that the LAPT and D-LEAT both show acceptable reliability and convergent validity, examining the extent to which they predict language outcomes is a high priority for future research.

Quality of input. Neither the D-LEAT nor LAPT directly captures information about interactional quality. The version of the LAPT that was administered in this study did not include any information about linguistic quality; however, the updated (optional) demographic questions that accompany the latest version of the LAPT do include questions about the interviewee's proficiency in various types of communication and how that may have changed as the child grew older. Still, the interviewee is not the child's only source of input, so even the updated LAPT does not eliminate the need to additionally collect information about the linguistic and/or interactional quality of the input to which the children have access.

Implications and Applications for Clinical Practice

Collecting language histories. First and foremost, we recommend that clinicians who work with DHH children take the time to collect and document a thorough language history. It is not sufficient to simply list the language(s) that was/were used in the child's environment; the child's language abilities will be more strongly determined by the input to which they had access. When identifying intervention strategies to achieve desired goals, language access profiles provide a framework for evaluating the match between the child's input to date and the desired outcomes. If limited access is still a significant part of a child's experience, the clinician may use that as an opportunity for informational counseling, and implement interventions designed to reduce it. Paying attention to how much opportunity a child has had to acquire a particular language is crucial for the interpretation of assessment results and for generating appropriate and effective intervention plans. Language access profiles are a key component of any DHH child's language history, and are worth the time it takes to obtain them.

We recognize that documenting a DHH child's history with language input is even more complex than it is for hearing children from multilingual homes. Not only is there the challenge of taking the child's perceptual abilities into account, but DHH children's input may also include various types of communication that are not always familiar to clinicians, and even the families themselves may need additional support in order to describe accurately, such as the differences between natural sign languages like ASL, sign-supported English, manually coded English, and cued English (not to mention other sign languages as well as sign-supported, manually coded, or cued versions of other spoken languages). We developed both the D-LEAT and the LAPT as a way of providing this additional support to clinicians and their clients. Although there is certainly room for improvement, we believe that even in their present state, these tools offer a significant improvement over the status quo.

Practical considerations. The LAPT and D-LEAT can be used with any DHH child; however, there are subtle differences that lead us to prefer one tool over the other in some circumstances. For children between ages birth and 3 years, clinicians may prefer the D-LEAT for its greater specificity about who exactly is providing what kinds of input. However, if the interviewer has limited time[1] or is not comfortable with spreadsheets, the present data reveal that LAPT estimates yield very similar overall estimates. For children between ages 3 and 12 years, the present findings indicate that there is no significant decrease in parent-reported confidence for children as old as 12;11 (years;months), whereas no such evidence is available for the D-LEAT. Another consideration is the availability of Internet access during the interview. The LAPT is designed to be administered online, whereas the D-LEAT does not require an Internet connection. Clinicians, researchers, and others who are interested in accessing either the LAPT or D-LEAT can indicate their interest at https://cphapps.temple.edu/surveys/?s=9T4A4WJRH3; training materials are in development in both ASL and English.

Conclusions

The present findings demonstrate that the LAPT is a viable alternative method for gathering information about the linguistic input that has been available to a DHH child during infancy and toddlerhood. The LAPT is particularly recommended for use with parents whose children are between 3 and 12 years old, but may also be used prospectively with children younger than 3 years of age. The estimates obtained from the LAPT show strong test–retest reliability. Despite adopting a less-detailed approach than the D-LEAT (currently the only other tool designed for this purpose), the LAPT also showed strong convergent validity with the D-LEAT. Future research is needed to investigate whether and how the LAPT (and D-LEAT) relate to language outcomes in DHH children during the preschool years and beyond.

[1]Administering the D-LEAT every 6 or 12 months reduces administration time and memory demands (for both the interviewer and interviewee).

Author Contributions

Matthew L. Hall: Conceptualization (Lead), Data curation (Lead), Formal analysis (Lead), Investigation (Lead), Methodology (Lead), Project administration (Lead), Resources (Lead), Software (Lead), Visualization (Lead), Writing – original draft (Lead), Writing – review & editing (Equal). **Stephanie De Anda:** Conceptualization (Supporting), Investigation (Supporting), Methodology (Supporting), Validation (Lead), Writing – original draft (Supporting), Writing – review & editing (Equal).

Data Availability Statement

De-identified data are available from the first author on request.

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References

American National Standards Institute. (1997). *S3.5-1997, Methods for the calculation of the speech intelligibility index* (pp. 90–119).

American Speech-Language-Hearing Association. (n.d.-a). *Bilingual service delivery* (Practice Portal). https://www.asha.org/practice-portal/professional-issues/bilingual-service-delivery/

American Speech-Language-Hearing Association. (n.d.-b). *Interprofessional education/interprofessional practice (IPE/IPP)*. https://www.asha.org/practice/ipe-ipp/

American Speech-Language-Hearing Association. (2016). *Scope of practice in speech-language pathology*. https://www.asha.org/policy/sp2016-00343/

Bagatto, M. P., & Scollie, S. D. (2013). Validation of the Parents' Evaluation of Aural/Oral Performance of Children (PEACH) rating scale. *Journal of the American Academy of Audiology, 24*(2), 121–125. https://doi.org/10.3766/jaaa.24.2.5

Bedore, L. M., Peña, E. D., Summers, C. L., Boerger, K. M., Resendiz, M. D., Greene, K., Bohman, T. M., & Gillam, R. B. (2012). The measure matters: Language dominance profiles across measures in Spanish–English bilingual children. *Bilingualism: Language and Cognition, 15*(3), 616–629. https://doi.org/10.1017/S1366728912000090

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Routledge.

Coninx, F., Weichbold, V., Tsiakpini, L., Autrique, E., Bescond, G., Tamas, L., Compernol, A., Georgescu, M., Koroleva, I., Le Maner-Idrissi, G., Liang, W., Madell, J., Mikić, B., Obrycka, A., Pankowska, A., Pascu, A., Popescu, R., Radulescu, L., Rauhamäki, T., . . . Brachmaier, J. (2009). Validation of the LittlEARS® Auditory Questionnaire in children with normal hearing. *International Journal of Pediatric Otorhinolaryngology, 73*(12), 1761–1768. https://doi.org/10.1016/j.ijporl.2009.09.036

Crowe, K., McLeod, S., & Ching, T. Y. C. (2012). The cultural and linguistic diversity of 3-year-old children with hearing loss. *Journal of Deaf Studies and Deaf Education, 17*(4), 421–438. https://doi.org/10.1093/deafed/ens028

Crowe, K., McLeod, S., McKinnon, D. H., & Ching, T. Y. (2015). Attitudes toward the capabilities of deaf and hard of hearing adults: Insights from the parents of deaf and hard of hearing children. *American Annals of the Deaf, 160*(1), 24–35. https://doi.org/10.1353/aad.2015.0013

DeAnda, S., Bosch, L., Poulin-Dubois, D., Zesiger, P., & Friend, M. (2016). The language exposure assessment tool: Quantifying language exposure in infants and children. *Journal of Speech, Language, and Hearing Research, 59*(6), 1346–1356. https://doi.org/10.1044/2016_JSLHR-L-15-0234

Dills, S., & Hall, M. L. (2021). More limitations of "communication mode" as a construct. *Deafness & Education International, 23*(4), 253–275. https://doi.org/10.1080/14643154.2021.1966160

Fabiano-Smith, L., & Goldstein, B. A. (2010). Phonological acquisition in bilingual Spanish–English speaking children. *Journal of Speech, Language, and Hearing Research, 53*(1), 160–178. https://doi.org/10.1044/1092-4388(2009/07-0064)

Gutiérrez-Clellen, V. F., & Kreiter, J. (2003). Understanding child bilingual acquisition using parent and teacher reports. *Applied Psycholinguistics, 24*(2), 267–288. https://doi.org/10.1017/S0142716403000158

Hall, M. L. (2020). The input matters: Assessing cumulative language access in deaf and hard of hearing individuals and populations. *Frontiers in Psychology, 11,* 1407. https://doi.org/10.3389/fpsyg.2020.01407

Hall, M. L., & De Anda, S. (2021). Measuring "Language Access Profiles" in deaf and hard-of-hearing children with the DHH Language Exposure Assessment Tool. *Journal of Speech, Language, and Hearing Research, 64*(1), 134–158. https://doi.org/10.1044/2020_JSLHR-20-00439

Houston, D. M. (2022). A framework for understanding the relation between spoken language input and outcomes for children with cochlear implants. *Child Development Perspectives, 16*(1), 60–66. https://doi.org/10.1111/cdep.12443

Kaščelan, D., Prevost, P., Serratrice, L., Tuller, L., Unsworth, S., & De Cat, C. (2021). A review of questionnaires quantifying bilingual experience in children: Do they document the same constructs? *Bilingualism: Language and Cognition, 25*(1), 29–41. https://doi.org/10.1017/S1366728921000390

Kronenberger, W. G., Bozell, H., Henning, S. C., Montgomery, C. J., Ditmars, A. M., & Pisoni, D. B. (2021). Functional hearing quality in prelingually deaf school-age children and adolescents with cochlear implants. *International Journal of Audiology, 60*(4), 282–292. https://doi.org/10.1080/14992027.2020.1826586

Levine, D., Strother-Garcia, K., Golinkoff, R. M., & Hirsh-Pasek, K. (2016). Language development in the first year of Life. *Otology & Neurotology, 37*(2), e56–e62. https://doi.org/10.1097/MAO.0000000000000908

McGregor, K. K., Williams, D., Hearst, S., & Johnson, A. C. (1997). The use of contrastive analysis in distinguishing difference from disorder. *American Journal of Speech-Language Pathology, 6*(3), 45–56. https://doi.org/10.1044/1058-0360.0603.45

Moeller, M. P., & Tomblin, J. B. (2015). An introduction to the outcomes of children with hearing loss study. *Ear and Hearing, 36*(Suppl. 1), 4S–13S. https://doi.org/10.1097/AUD.0000000000000210

Pearson, B. Z., Fernández, S. C., Lewedeg, V., & Oller, D. K. (1997). The relation of input factors to lexical learning by bilingual infants. *Applied Psycholinguistics, 18*(1), 41–58. https://doi.org/10.1017/S0142716400009863

Pedersen, H. F., Nichol, S., Swartwout, N., & Conn, D. R. (2021). Canadian families' decisions of communication options* for children who are deaf or hard of hearing: An initial exploration. *Journal of Early Hearing Detection and Intervention, 6*(1), 77–89.

Peña, E. D. (2007). Lost in translation: Methodological considerations in cross-cultural research. *Child Development, 78*(4), 1255–1264. https://doi.org/10.1111/j.1467-8624.2007.01064.x

Place, S., & Hoff, E. (2011). Properties of dual language exposure that influence 2-year-olds' bilingual proficiency. *Child Development, 82*(6), 1834–1849. https://doi.org/10.1111/j.1467-8624.2011.01660.x

Porter, A., Creed, P., Hood, M., & Ching, T. Y. (2018). Parental decision-making and deaf children: A systematic literature review. *The Journal of Deaf Studies and Deaf Education, 23*(4), 295–306. https://doi.org/10.1093/deafed/eny019

Shipley, K. G., & McAfee, J. G. (2019). *Assessment in speech-language pathology: A resource manual* (6th ed.). Plural.

Stredler-Brown, A. (2010). Communication choices and outcomes during the early years: An assessment and evidence-based approach. In M. Marschark & P. E. Spencer (Eds.), *Oxford handbook of deaf studies, language, and education* (Vol. 2, pp. 292–315). Oxford University Press.

Streiner, D. L., Norman, G. R., & Cairney, J. (2015). *Health measurement scales: A practical guide to their development and use*. Oxford University Press.

Üstün, T. B., Chatterji, S., Bickenbach, J., Kostanjsek, N., & Schneider, M. (2003). The International Classification of Functioning, Disability and Health: A new tool for understanding disability and health. *Disability and Rehabilitation, 25*(11–12), 565–571. https://doi.org/10.1080/0963828031000137063

Xu, D., Yapanel, U., & Gray, S. (2009). *Reliability of the LENA Language Environment Analysis System in young children's natural home environment*. LENA Foundation.

Zimmerman-Phillips, S., Osberger, M. J., & Robbins, A. M. (1997). *Infant–toddler meaningful auditory integration scale (IT-MAIS)*. Advanced Bionics Corporation.